US009479245B2

(12) **United States Patent**
Kamimura et al.

(10) **Patent No.: US 9,479,245 B2**
(45) **Date of Patent: Oct. 25, 2016**

(54) **RELAY APPARATUS AND COMPUTER-READABLE RECORDING MEDIUM**

(71) Applicant: **SoftBank BB Corp.**, Tokyo (JP)

(72) Inventors: **Masayuki Kamimura**, Tokyo (JP); **Yosuke Mitsuya**, Tokyo (JP); **Tadashi Suzuki**, Miyagi (JP)

(73) Assignee: **SoftBank Corp.**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/622,923**

(22) Filed: **Feb. 16, 2015**

(65) **Prior Publication Data**

US 2015/0162973 A1 Jun. 11, 2015

Related U.S. Application Data

(63) Continuation of application No. PCT/JP2013/005054, filed on Aug. 27, 2013.

(30) **Foreign Application Priority Data**

Sep. 26, 2012 (JP) 2012-212153

(51) **Int. Cl.**
H04B 7/14 (2006.01)
H04B 17/02 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***H04B 7/15528*** (2013.01); ***H04W 16/26*** (2013.01); *H04W 24/02* (2013.01); *H04W 88/04* (2013.01)

(58) **Field of Classification Search**
CPC H04B 7/14
USPC 455/9, 7, 16, 12.1
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,972,346 A * 11/1990 Kawano H04B 7/15535 455/21
2004/0203911 A1* 10/2004 Masuda H04B 7/2606 455/456.1

(Continued)

FOREIGN PATENT DOCUMENTS

JP 2006-100884 A 4/2006
JP 2010-226668 A 10/2010
JP 2012-010294 A 1/2012

OTHER PUBLICATIONS

International Search Report for International Application No. PCT/JP2013/005054, issued by the Japanese Patent Office on Oct. 29, 2013.

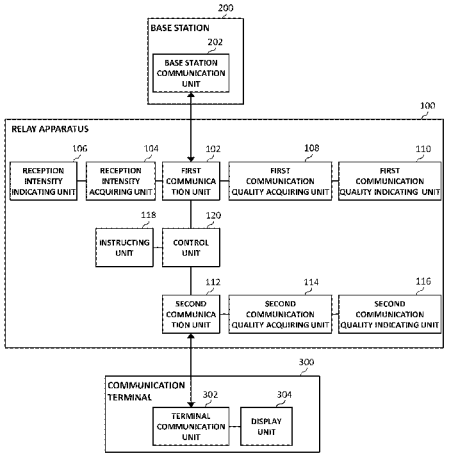
(Continued)

Primary Examiner — Tilahun B Gesesse

(57) **ABSTRACT**

Even if a relay apparatus such as a mobile router indicates the radio wave reception intensity as low, medium, and high levels, a user using the relay apparatus such as a mobile router cannot recognize that the communication quality is lowered because the radio wave reception intensity is too high. A relay apparatus that relays wireless communication between a communication terminal and a base station is provided, the relay apparatus comprising: a first communication quality acquiring unit that acquires first communication quality of communication with the base station; a first communication quality indicating unit that indicates the first communication quality acquired by the first communication quality acquiring unit; a reception intensity acquiring unit that acquires reception intensity of a radio wave received from the base station; and a reception intensity indicating unit that indicates that the reception intensity acquired by the reception intensity acquiring unit has exceeded a predetermined threshold.

17 Claims, 10 Drawing Sheets



(51) **Int. Cl.**

H04B 7/15	(2006.01)
H04B 7/155	(2006.01)
H04W 16/26	(2009.01)
H04W 24/02	(2009.01)
H04W 88/04	(2009.01)

(56) **References Cited**

U.S. PATENT DOCUMENTS

2005/0181798	A1*	8/2005	Monden	H04L 45/00 455/446
2008/0008165	A1*	1/2008	Ikeda	H04L 45/00 370/360
2010/0008285	A1*	1/2010	Kuroda	H04W 36/0055 370/315
2010/0067533	A1*	3/2010	Yoshida	H04L 43/0847 370/401
2010/0232343	A1*	9/2010	Xu	H04B 7/155 370/315
2010/0330902	A1*	12/2010	Fujita	H04B 7/15557 455/7
2012/0188890	A1	7/2012	Tabata	
2012/0213148	A1*	8/2012	Saito	H04B 7/15542 370/315
2013/0267223	A1*	10/2013	Tajima	H04W 76/028 455/423

OTHER PUBLICATIONS

International Preliminary Report on Patentability for International Application No. PCT/JP2013/005054, issued by the International Bureau of WIPO on Apr. 9, 2015.

* cited by examiner

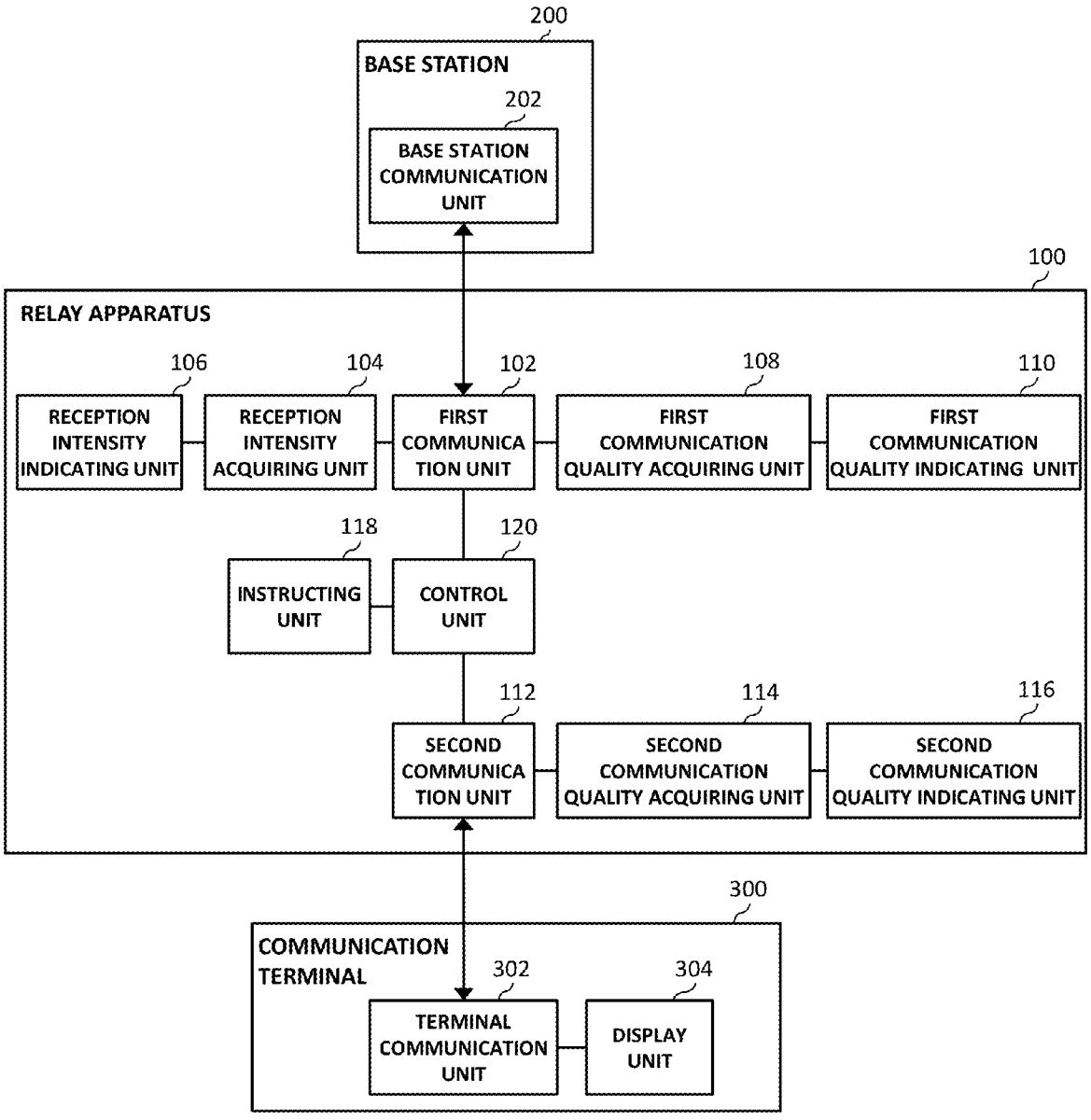

200
BASE STATION
202
BASE STATION COMMUNICATION UNIT
100
RELAY APPARATUS
106
RECEPTION INTENSITY INDICATING UNIT
104
RECEPTION INTENSITY ACQUIRING UNIT
102
FIRST COMMUNICATION UNIT
108
FIRST COMMUNICATION QUALITY ACQUIRING UNIT
110
FIRST COMMUNICATION QUALITY INDICATING UNIT
118
INSTRUCTING UNIT
120
CONTROL UNIT
112
SECOND COMMUNICATION UNIT
114
SECOND COMMUNICATION QUALITY ACQUIRING UNIT
116
SECOND COMMUNICATION QUALITY INDICATING UNIT
300
COMMUNICATION TERMINAL
302
TERMINAL COMMUNICATION UNIT
304
DISPLAY UNIT

FIG.1

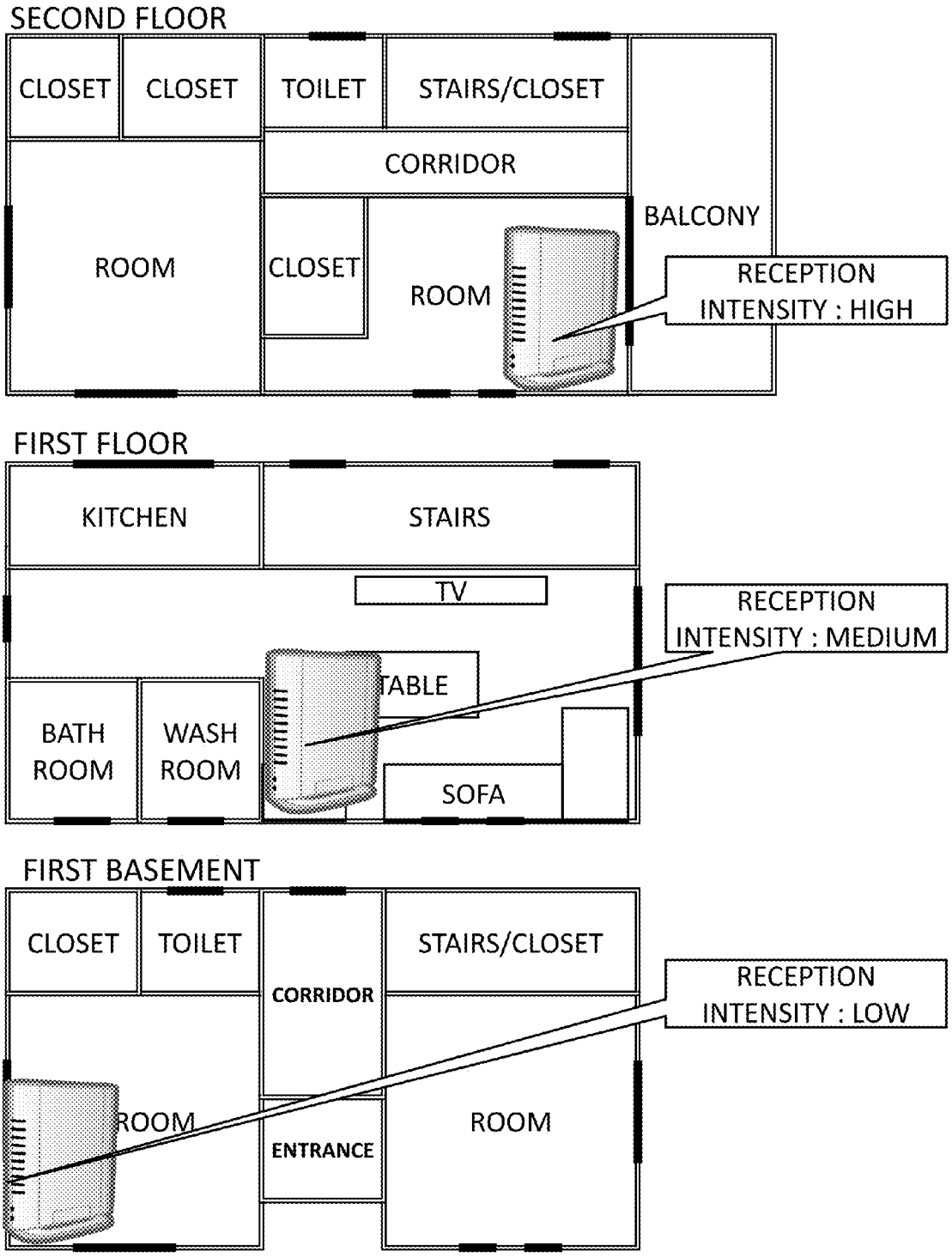

SECOND FLOOR
CLOSET
CLOSET
TOILET
STAIRS/CLOSET
CORRIDOR
BALCONY
ROOM
CLOSET
ROOM
RECEPTION
INTENSITY : HIGH
FIRST FLOOR
KITCHEN
STAIRS
TV
RECEPTION
INTENSITY : MEDIUM
TABLE
BATH
ROOM
WASH
ROOM
SOFA
FIRST BASEMENT
CLOSET
TOILET
CORRIDOR
STAIRS/CLOSET
RECEPTION
INTENSITY : LOW
ROOM
ENTRANCE
ROOM

FIG.2

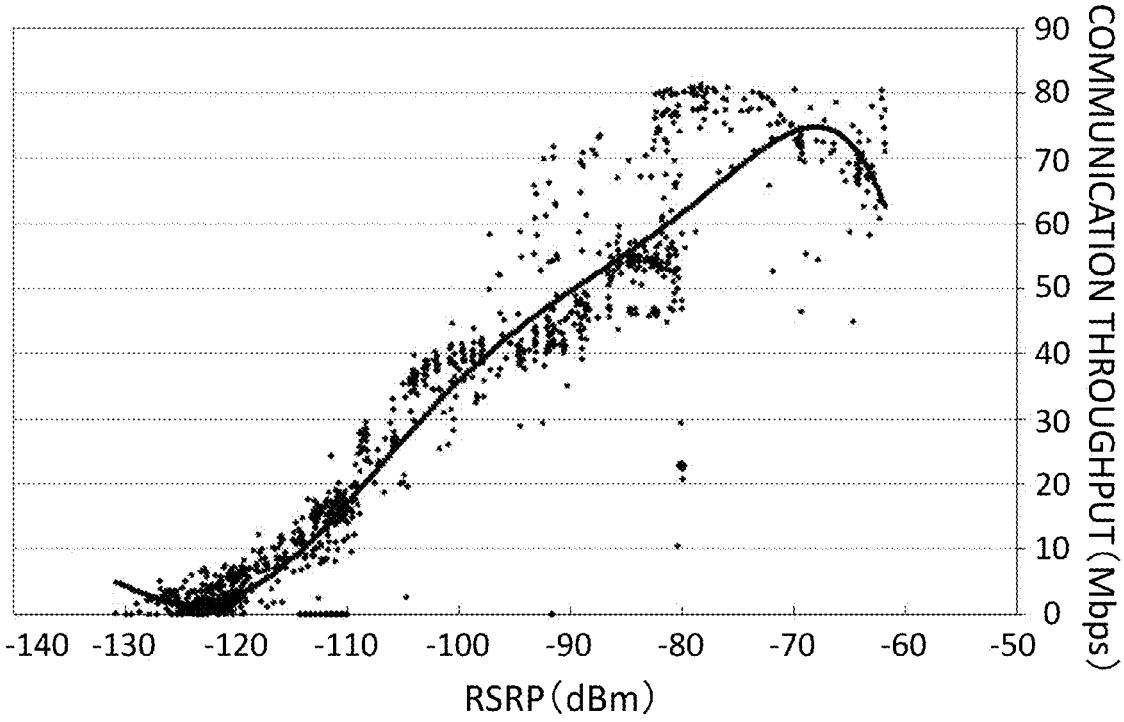

90
80
70
60
50
40
30
20
10
0
COMMUNICATION THROUGHPUT (Mbps)
-140
-130
-120
-110
-100
-90
-80
-70
-60
-50
RSRP (dBm)

FIG.3

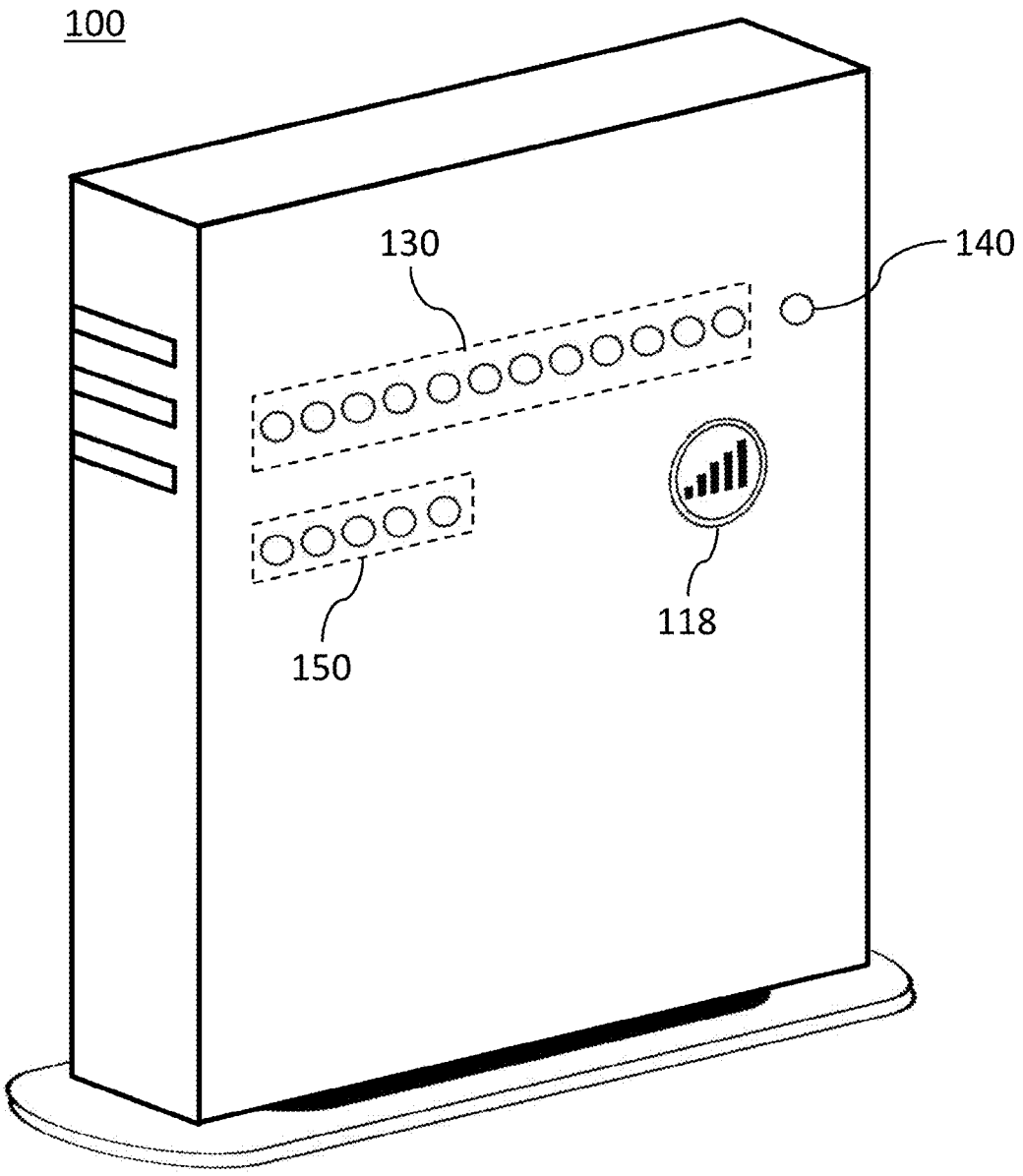


FIG.4

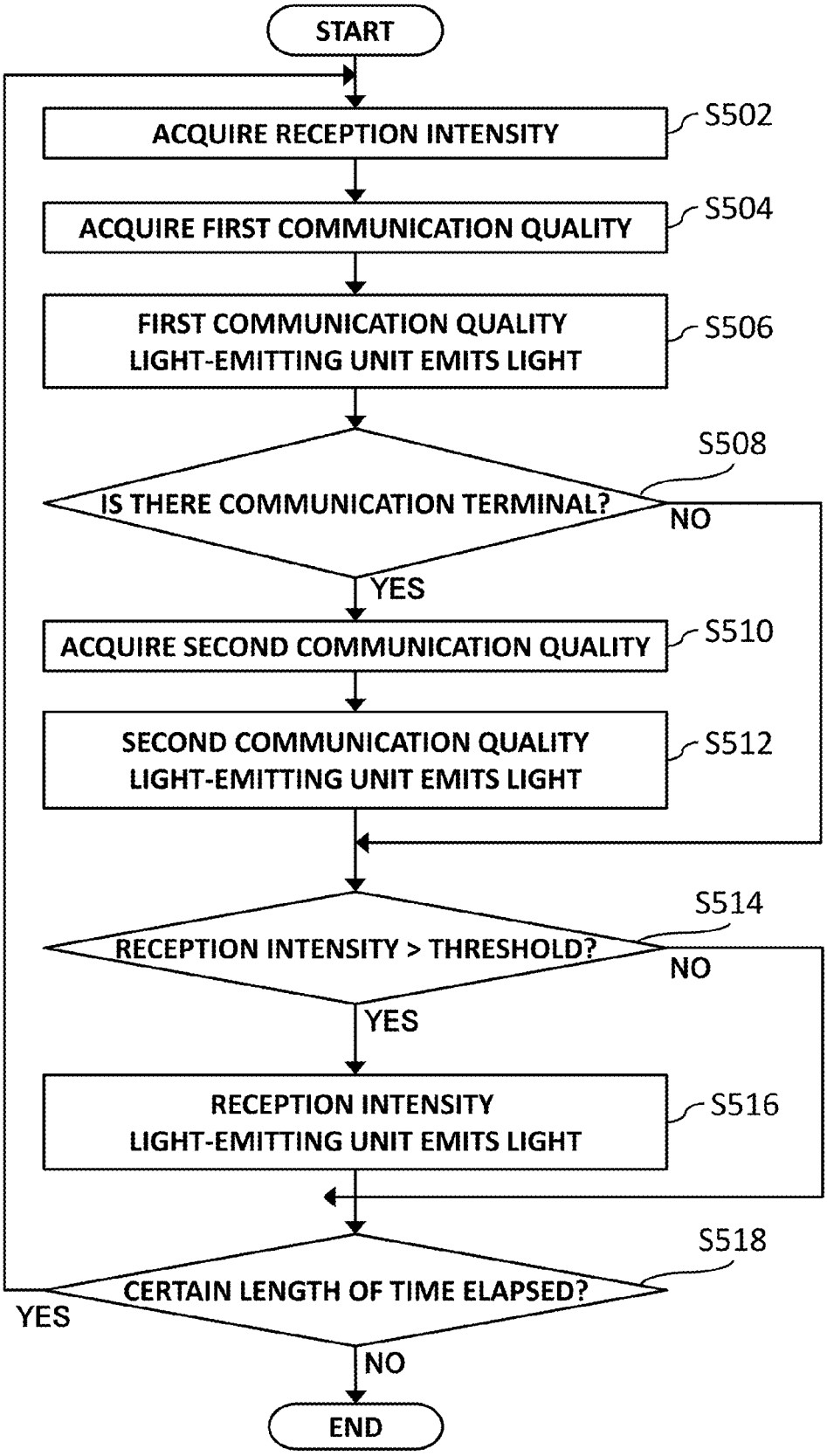

START
ACQUIRE RECEPTION INTENSITY
S502
ACQUIRE FIRST COMMUNICATION QUALITY
S504
FIRST COMMUNICATION QUALITY
LIGHT-EMITTING UNIT EMITS LIGHT
S506
IS THERE COMMUNICATION TERMINAL?
S508
NO
YES
ACQUIRE SECOND COMMUNICATION QUALITY
S510
SECOND COMMUNICATION QUALITY
LIGHT-EMITTING UNIT EMITS LIGHT
S512
RECEPTION INTENSITY > THRESHOLD?
S514
NO
YES
RECEPTION INTENSITY
LIGHT-EMITTING UNIT EMITS LIGHT
S516
CERTAIN LENGTH OF TIME ELAPSED?
S518
YES
NO
END

FIG.5

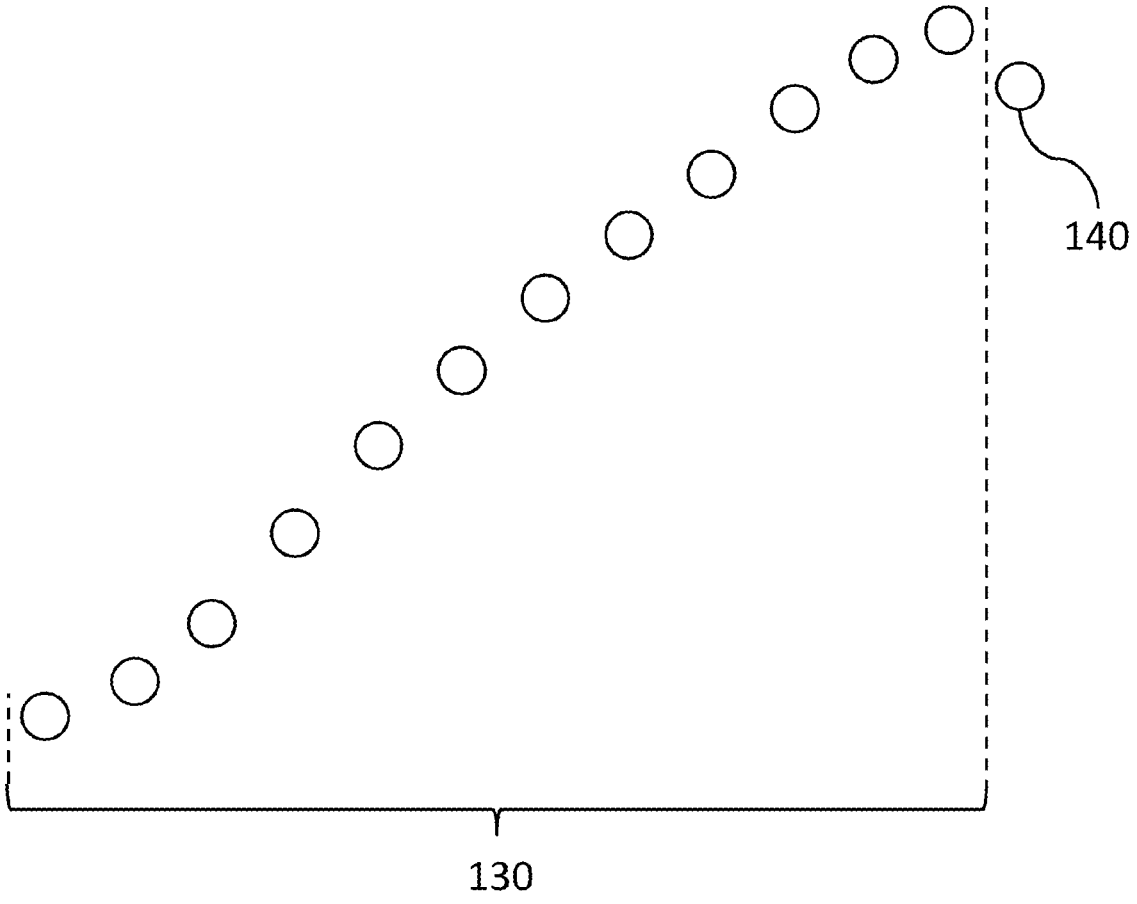


FIG.6

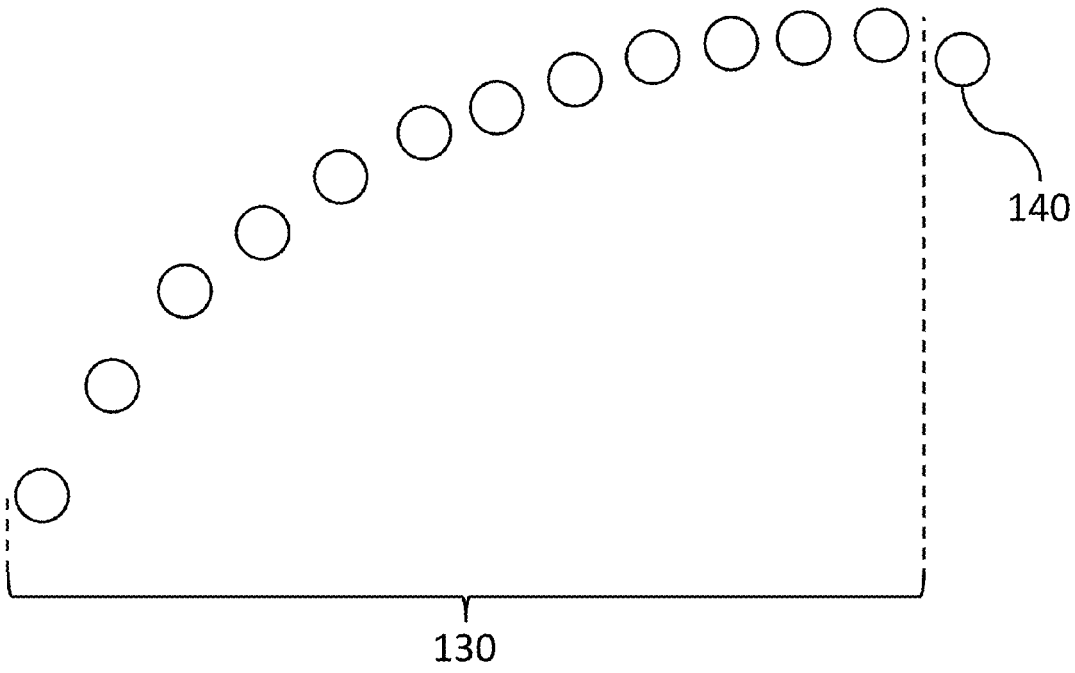


FIG. 7

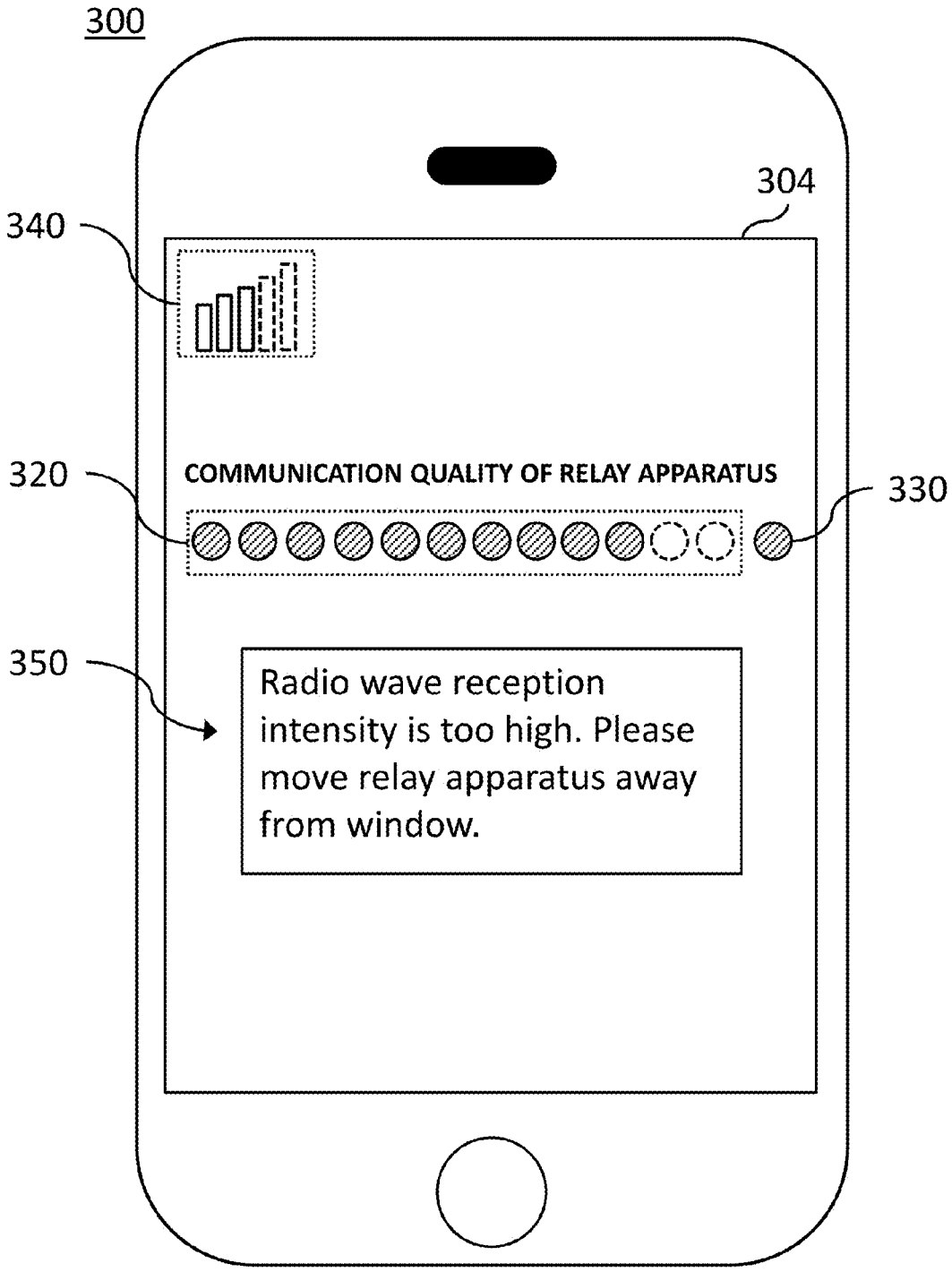

300
304
340
320
COMMUNICATION QUALITY OF RELAY APPARATUS
330
350
Radio wave reception intensity is too high. Please move relay apparatus away from window.

FIG.8

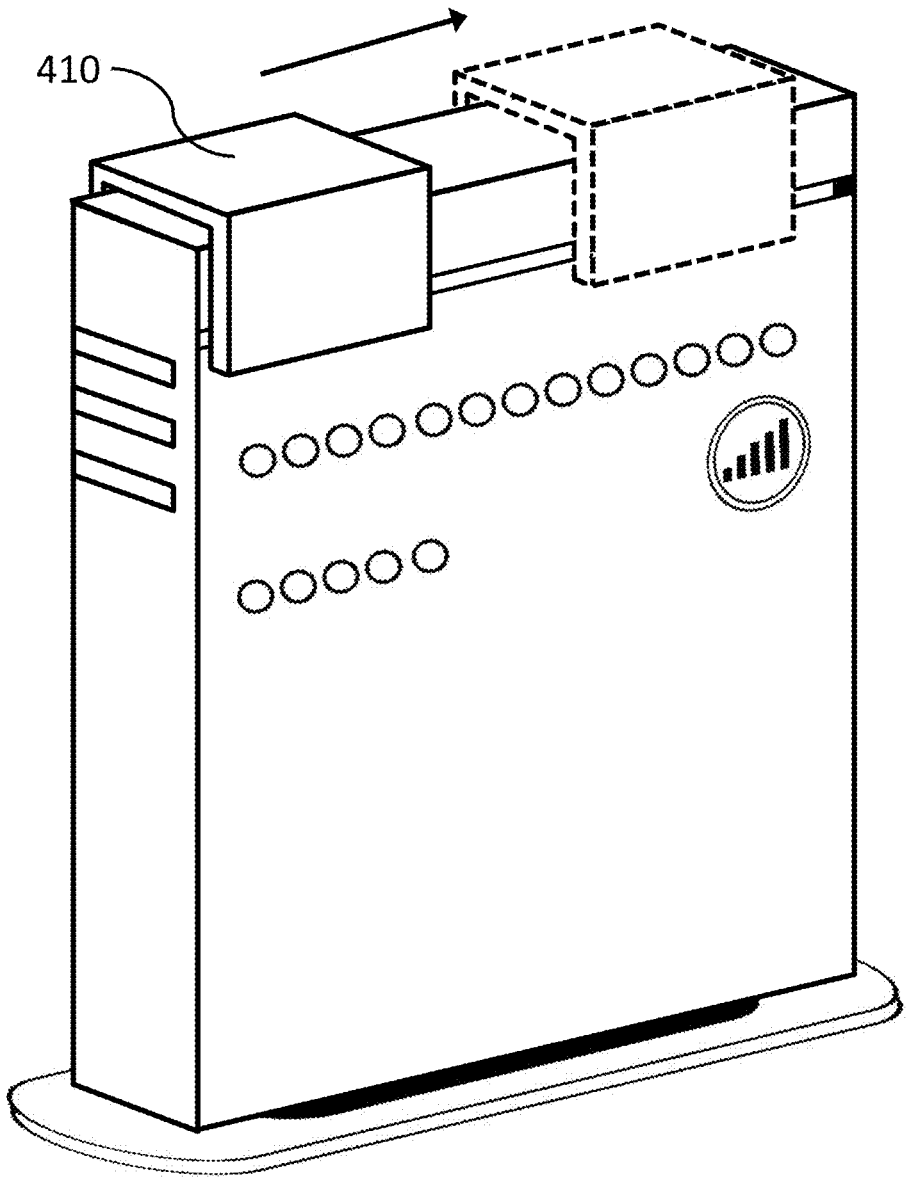


FIG.9

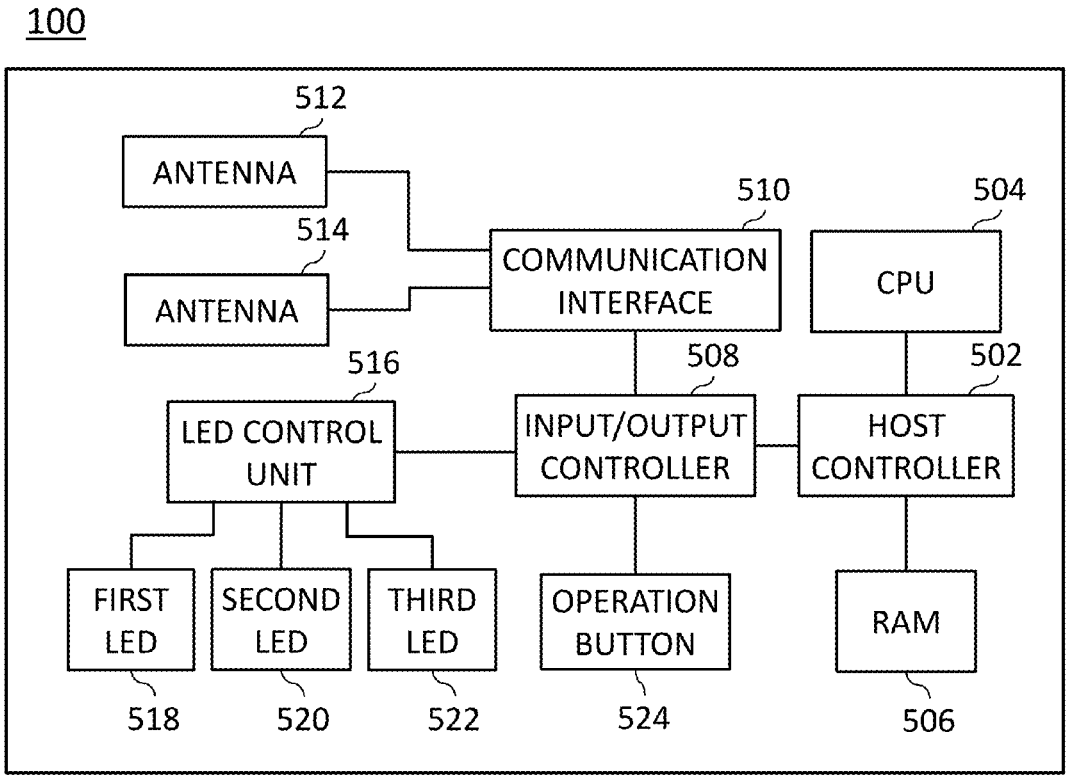

100
512
ANTENNA
514
ANTENNA
510
COMMUNICATION INTERFACE
504
CPU
516
LED CONTROL UNIT
508
INPUT/OUTPUT CONTROLLER
502
HOST CONTROLLER
FIRST LED
SECOND LED
THIRD LED
OPERATION BUTTON
RAM
518
520
522
524
506

FIG.10

RELAY APPARATUS AND COMPUTER-READABLE RECORDING MEDIUM

The contents of the following Japanese patent application are incorporated herein by reference: No. 2012-212153 filed on Sep. 26, 2012.

BACKGROUND

1. Technical Field

The present invention relates to a relay apparatus and a computer-readable recording medium.

2. Related Art

A mobile router that acquires radio wave reception intensity separately as low, medium, and high levels is known (for example, Patent Literature 1).

Patent Literature 1: Japanese Patent Application Publication No. 2010-226668

However, even if a relay apparatus such as a mobile router indicates the radio wave reception intensity as low, medium, and high levels, a user who uses the relay apparatus such as a mobile router cannot recognize that the communication quality is lowered because the radio wave reception intensity is too high.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** schematically illustrates the functional configuration of a relay apparatus **100**.

FIG. **2** schematically illustrates variation in reception intensity depending of locations where a home-installation type relay apparatus **100** is arranged.

FIG. **3** illustrates experimental results obtained by actually measuring the RSRP of radio waves received by the relay apparatus **100** from a base station **200**, and the communication throughput between the relay apparatus **100** and the base station **200**.

FIG. **4** schematically illustrates one example of the external appearance of the relay apparatus **100**.

FIG. **5** illustrates one example of a flowchart of an indication process by the relay apparatus **100**.

FIG. **6** schematically illustrates another array example of a plurality of first communication quality light-emitting units **130** and a reception intensity light-emitting unit **140**.

FIG. **7** schematically illustrates another array example of the plurality of first communication quality light-emitting units **130** and the reception intensity light-emitting unit **140**.

FIG. **8** schematically illustrates a display example of a display unit **304** of a communication terminal **300**.

FIG. **9** schematically illustrates the relay apparatus **100** comprising a movable antenna cover **410**.

FIG. **10** illustrates one example of the hardware construction of the relay apparatus **100**.

DESCRIPTION OF EXEMPLARY EMBODIMENTS

Hereinafter, (some) embodiment(s) of the present invention will be described. The embodiment(s) do(es) not limit the invention according to the claims, and all the combinations of the features described in the embodiment(s) are not necessarily essential to means provided by aspects of the invention.

FIG. **1** schematically illustrates the functional configuration of a relay apparatus **100**. The relay apparatus **100** relays wireless communication between a base station **200** and a communication terminal **300**. The relay apparatus **100** comprises a first communication unit **102**, a reception intensity acquiring unit **104**, a reception intensity indicating unit **106**, a first communication quality acquiring unit **108**, a first communication quality indicating unit **110**, a second communication unit **112**, a second communication quality acquiring unit **114**, a second communication quality indicating unit **116**, an instructing unit **118**, and a control unit **120**.

The first communication unit **102** communicates with the base station **200** in a first wireless communication mode.

The first wireless communication mode is, for example, the LTE (Long Term Evolution). Also, the first wireless communication mode may be any of the third generation mobile communication mode (3G), the HSDPA (High Speed Downlink Packet Access), and the mobile WiMAX.

The reception intensity acquiring unit **104** acquires the reception intensity of radio waves received from the base station **200**. The reception intensity acquiring unit **104**, for example, measures, as the reception intensity, the RSRP (Reference Signal Received Power) of radio waves received from the base station **200**.

The reception intensity indicating unit **106** indicates that the reception intensity acquired by the reception intensity acquiring unit **104** has exceeded a predetermined threshold. The predetermined threshold may be a threshold at which the communication quality between the relay apparatus **100** and the base station **200** lowers because the radio wave intensity of radio waves received from the base station **200** is too high.

The first communication quality acquiring unit **108** acquires first communication quality of communication with the base station **200**. The first communication quality acquiring unit **108** may measure, as the first communication quality, the communication throughput of communication with the base station **200**. Also, the first communication quality acquiring unit **108** may calculate, as the first communication quality, the RSRQ of communication with the base station **200** (Reference Signal Received Quality). Also, the first communication quality acquiring unit **108** may calculate, as the first communication quality, the SINR (Signal to Interference and Noise Ratio) of signals received from the base station **200**.

Also, the first communication quality acquiring unit **108** may acquire the first communication quality based on the RSRP, the RSRQ, and the SINR. For example, the first communication quality acquiring unit **108** may acquire, as the first communication quality, a value obtained by weighting respectively and adding together the RSRP, the RSRQ, and the SINR. Furthermore, the first communication quality acquiring unit **108** may calculate the first communication quality by taking into consideration the degree of interference of radio waves emitted from other equipment.

The first communication quality indicating unit **110** indicates the first communication quality acquired by the first communication quality acquiring unit **108**. The first communication quality indicating unit **110** may indicate to which communication quality level among a plurality of communication quality levels the first communication quality acquired by the first communication quality acquiring unit **108** corresponds.

The second communication unit **112** communicates with the communication terminal **300** in a second wireless communication mode. The second wireless communication mode is, for example, Wi-Fi (registered trademark). The second wireless communication mode may be a wireless

LAN other than Wi-Fi, and may be a short-range wireless communication mode such as Bluetooth (registered trademark).

The second communication quality acquiring unit **114** acquires second communication quality of communication with the communication terminal **300**. The second communication quality acquiring unit **114** may measure, as the second communication quality, the signal intensity of signals received from the communication terminal **300**. Also, the second communication quality acquiring unit **114** acquires influence of radio waves emitted from another relay apparatus (not illustrated) on the second communication quality. The other relay apparatus may be, for example, a wireless LAN access point. The second communication quality acquiring unit **114** may measure the signal intensity of signals received from the other relay apparatus. Also, the second communication quality acquiring unit **114** may measure the signal frequency of signals received from the other relay apparatus. The second communication quality acquiring unit **114** may acquire influence of radio waves emitted from the other relay apparatus on the second communication quality based on at least any of the measured signal intensity and signal frequency of signals received from the other relay apparatus.

Also, the second communication quality acquiring unit **114** may measure, as the second communication quality, the communication throughput between the relay apparatus **100** and the communication terminal **300**. The second communication quality acquiring unit **114** may, for example, execute a ping command for the communication terminal **300**, and analyze a response to the ping command, the data link speed, and the presence/absence of data retransmission in the MAC layer to measure the communication throughput between the relay apparatus **100** and the communication terminal **300**.

Also, the second communication quality acquiring unit **114** may receive the second communication quality from the communication terminal **300**. For example, the second communication quality acquiring unit **114** may receive, from the communication terminal **300**, the second communication quality measured by the communication terminal **300** during communication with the relay apparatus **100**.

The second communication quality indicating unit **116** indicates the second communication quality acquired by the second communication quality acquiring unit **114**. The second communication quality acquiring unit **114** may indicate to which communication quality level among a plurality of communication quality levels the second communication quality acquired by the second communication quality acquiring unit **114** corresponds.

The instructing unit **118** instructs the reception intensity acquiring unit **104** to acquire the reception intensity of radio waves received from base station **200** Also, the instructing unit **118** instructs the first communication quality acquiring unit **108** to acquire the first communication quality of communication with the base station **200**. Also, the instructing unit **118** instructs the second communication quality acquiring unit **114** to acquire the second communication quality of communication with the communication terminal **300**.

The instructing unit **118** may have one operation button. The instructing unit **118** may execute the instructions of the reception intensity acquiring unit **104**, the first communication quality acquiring unit **108**, and the second communication quality acquiring unit **114** upon detecting pressing of the operation button.

When pressing of the operation button is detected, the instructing unit **118** may continue the instructions of the reception intensity acquiring unit **104**, the first communication quality acquiring unit **108**, and the second communication quality acquiring unit **114** for a certain length of time. For example, when the certain length of time is set at three minutes, the acquisition and indication of the reception intensity and communication quality are executed continuously for three minutes.

The operation button may be a toggle button. When pressing of the operation button is detected, the instructing unit **118** may continuously execute the instructions of the reception intensity acquiring unit **104**, the first communication quality acquiring unit **108**, and the second communication quality acquiring unit **114**, and stop the instructions when pressing of the operation button is detected again. Note that the instructing unit **118** may have three operation buttons respectively for executing instructions of the reception intensity acquiring unit **104**, the first communication quality acquiring unit **108**, and the second communication quality acquiring unit **114**.

The control unit **120** controls the first communication unit **102**, the reception intensity acquiring unit **104**, the reception intensity indicating unit **106**, the first communication quality acquiring unit **108**, the first communication quality indicating unit **110**, the second communication unit **112**, the second communication quality acquiring unit **114**, the second communication quality indicating unit **116**, and the instructing unit **118**.

The relay apparatus **100** may have a plurality of light-emitting units. For example, the relay apparatus **100** may have an LED indicator for indicating the first communication quality. The first communication quality indicating unit **110** may indicate the first communication quality by the LED indicator. Also, the relay apparatus **100** may have an LED indicator for indicating the second communication quality. The second communication quality indicating unit **116** may indicate the second communication quality by the LED indicator. Also, the relay apparatus **100** may have an LED for indicating that the reception intensity acquired by the reception intensity acquiring unit **104** has exceeded a predetermined threshold. The reception intensity indicating unit **106** may cause the LED to emit light to indicate that the reception intensity has exceeded a predetermined threshold.

Also, the relay apparatus **100** may have a display unit. The first communication quality indicating unit **110** may display the first communication quality on the display unit. The first communication quality indicating unit **110** may display the first communication quality as an indicator on the display unit. Also, the first communication quality indicating unit **110** may display the first communication quality as numerical data on the display unit.

The second communication quality indicating unit **116** may display the second communication quality on the display unit. The second communication quality indicating unit **116** may display the second communication quality as an indicator on the display unit. Also, the second communication quality indicating unit **116** may display the second communication quality as numerical data on the display unit.

Also, the reception intensity indicating unit **106** may display on the display unit that the reception intensity acquired by the reception intensity acquiring unit **104** has exceeded a predetermined threshold. The reception intensity indicating unit **106** may display, as text data on the display unit, that the reception intensity has exceeded a predetermined threshold. Also, the reception intensity indicating unit

106 may display on the display unit an object that indicates that the reception intensity has exceeded a predetermined threshold.

The base station **200** comprises a base station communication unit **202** that communicates with the first communication unit **102** of the relay apparatus **100**. The base station **200** may be an LTE base station, and may be any of 3G, HSDPA and mobile WiMAX base stations.

The communication terminal **300** comprises a terminal communication unit **302** to communicate with the second communication unit **112** of the relay apparatus **100**, and a display unit **304**. The communication terminal **300** is equipment capable of communicating with the relay apparatus **100**, and may be, for example, a smartphone, a tablet terminal, a PC terminal, or the like.

The first communication quality indicating unit **110** may indicate the relay apparatus **100** user of the first communication quality by displaying the first communication quality on the display unit **304**. Also, the second communication quality indicating unit **116** may indicate the second communication quality by displaying the second communication quality on the display unit **304**. Also, the reception intensity indicating unit **106** may display, on the display unit **304**, that the reception intensity acquired by the reception intensity acquiring unit **104** has exceeded a predetermined threshold.

FIG. **2** schematically illustrates variation in reception intensity depending of locations where a home-installation type relay apparatus **100** is arranged. As illustrated in FIG. **2**, it has been known that the reception intensity becomes high at locations, such as a window side on a second floor, where there are few blocking objects that block radio waves, and the reception intensity becomes low at locations, such as a basement, where there are many blocking objects. Accordingly, in general, the relay apparatus **100** is in many cases arranged at locations where there are as few blocking objects as possible so as to improve the communication quality by increasing the reception intensity. However, increasing the radio wave reception intensity does not necessarily improve the communication quality.

FIG. **3** illustrates experimental results obtained by actually measuring the RSRP of radio waves received by the relay apparatus **100** from the base station **200**, and the communication throughput between the relay apparatus **100** and the base station **200**. The horizontal axis indicates the RSRP, and the vertical axis indicates the communication throughput.

As illustrated in FIG. **3**, until the value of RSRP increases to around −68 dBm, higher RSRP leads to higher communication throughput. However, after the value of RSRP exceeds around −68 dBm, higher RSRP leads to lower communication throughput. In this manner, when the reception intensity of radio waves received from the base station **200** is too high to cause saturation, the communication throughput lowers.

To cope with this, the relay apparatus **100** according to the present embodiment indicates the communication quality of communication with the base station **200** and also indicates that the reception intensity of radio waves received from the base station **200** has exceeded a predetermined threshold. The predetermined threshold may be, for example, −65 dBm. Also, the predetermined threshold may be, for example, set by a user who has checked the experimental results as illustrated in FIG. **3**.

FIG. **4** schematically illustrates one example of the external appearance of the relay apparatus **100**. The relay apparatus **100** illustrated in FIG. **4** comprises, on its side surface, the instructing unit **118** having an operation button, a plurality of first communication quality light-emitting units **130**, and a reception intensity light-emitting unit **140**. The plurality of first communication quality light-emitting units **130** and the reception intensity light-emitting unit **140** are LEDs for example.

The plurality of first communication quality light-emitting units **130** correspond to respective ones of a plurality of communication quality levels of communication with the base station **200**. The plurality of first communication quality light-emitting units **130** may be arrayed in the order of corresponding communication quality levels. FIG. **4** illustrates an example in which the plurality of first communication quality light-emitting units **130** are arrayed such that the leftmost one, as seen when looking at the figure, corresponds to the lowest communication quality level, and the communication quality level increases as the position of a first communication quality light-emitting unit **130** shifts rightward as seen when looking at the figure.

The first communication quality indicating unit **110** may indicate the first communication quality by causing a first communication quality light-emitting unit **130**, among the plurality of first communication quality light-emitting units **130**, that corresponds to the first communication quality acquired by the first communication quality acquiring unit **108** to emit light. The first communication quality indicating unit **110** may cause, in addition to the first communication quality light-emitting unit **130** that corresponds to the first communication quality, first communication quality light-emitting units **130** that correspond to communication quality that is lower than the first communication quality to emit light. For example, when the first communication quality corresponds to the fourth first communication quality light-emitting unit **130** as counted from the left end, the first communication quality indicating unit **110** may cause all the four, first to fourth, first communication quality light-emitting units **130** as counted from the left end to emit light.

The plurality of first communication quality light-emitting units **130** may emit light of different colors depending on corresponding communication quality levels. For example, wavelengths of light emitted by the plurality of first communication quality light-emitting units **130** decrease according to the order of the plurality of communication quality levels. As a specific example, the leftmost first communication quality light-emitting unit **130** may emit red light, the next adjacent two first communication quality light-emitting units **130** may emit orange light, the next adjacent three first communication quality light-emitting units **130** may emit yellow, the next adjacent four first communication quality light-emitting units **130** may emit green light, and the next adjacent two first communication quality light-emitting units **130** may emit blue light.

Thereby, it is possible to allow the relay apparatus **100** user to intuitively recognize differences of the communication quality. Note that the plurality of first communication quality light-emitting units **130** may respectively have light sources, and the plurality of first communication quality light-emitting units **130** may share one light source.

The reception intensity light-emitting unit **140** may be arranged at any position on a surface of the relay apparatus **100**, but is preferably arranged in the vicinity of the plurality of first communication quality light-emitting units **130** so as to be within the visual field of a user together with the plurality of first communication quality light-emitting units **130**. The reception intensity light-emitting unit **140** may be arranged at a position adjacent to the first communication quality light-emitting unit **130** that corresponds to the highest communication quality level among the plurality of first

communication quality light-emitting units **130**. The reception intensity indicating unit **106** may indicate that the reception intensity acquired by the reception intensity acquiring unit **104** has exceeded a predetermined threshold by causing the reception intensity light-emitting unit **140** to emit light when the reception intensity has exceeded the predetermined threshold.

The relay apparatus **100** user can arrange the relay apparatus **100** at an appropriate position where the reception intensity is not too high, but the communication quality is high, by arranging the relay apparatus **100** so as not to cause the reception intensity light-emitting unit **140** to emit light, but to cause a first communication quality light-emitting unit **130** that corresponds to higher communication quality to emit light. Also, when the reception intensity light-emitting unit **140** happens to emit light, the relay apparatus **100** user can recognize that, by moving the relay apparatus **100** to a position where the reception intensity of radio waves from the base station **200** become lower, the communication quality can be improved.

FIG. **5** illustrates one example of a flowchart of an indication process by the relay apparatus **100**. The flowchart illustrated in FIG. **5** starts when an instruction from the instructing unit **118** is executed. At a step S**502**, the reception intensity acquiring unit **104** acquires the reception intensity of radio waves received from the base station **200**.

At a step S**504**, the first communication quality acquiring unit **108** acquires the first communication quality of communication with the base station **200**. At a step S**506**, the first communication quality indicating unit **110** causes the first communication quality light-emitting unit **130** to emit light to indicate the first communication quality acquired at the step S**504**.

At a step S**508**, the control unit **120** judges whether there is the communication terminal **300** that has established communication with the relay apparatus **100**. If it is judged by the control unit **120** that there is the communication terminal **300** that has established communication, the process proceeds to a step S**510**, and if not, the process proceeds to a step S**514**.

At the step S**510**, the second communication quality acquiring unit **114** acquires the second communication quality of communication with the communication terminal **300**. At a step S**512**, the second communication quality indicating unit **116** causes a second communication quality light-emitting unit **150** to emit light to indicate the second communication quality acquired at the step S**510**.

At the step S**514**, the control unit **120** judges whether the reception intensity acquired at the step S**502** has exceeded a predetermined threshold. If it is judged by the control unit **120** that the reception intensity has exceeded the predetermined threshold, the process proceeds to a step S**516**, and if not, the process proceeds to a step S**518**. At the step S**516**, the reception intensity indicating unit **106** causes the reception intensity light-emitting unit **140** to emit light to indicate that the reception intensity has exceeded the predetermined threshold.

At the step S**518**, the control unit **120** judges whether a predetermined certain length of time has elapsed since an operation button was pressed. If it is judged by the control unit **120** that the certain length of time has not elapsed, the process returns to the step S**502**, and if it is judged the certain length of time has elapsed, the process ends.

As described above, the relay apparatus **100** continuously indicates the first communication quality and the second communication quality until the certain length of time elapses since the operation button is pressed. If the reception intensity of radio waves from the base station **200** exceeds the predetermined threshold when the first communication quality and the second communication quality are continuously being indicated, the reception intensity light-emitting unit **140** is caused to emit light to indicate that the reception intensity is too high.

FIG. **6** schematically illustrates another array example of the plurality of first communication quality light-emitting units **130** and the reception intensity light-emitting unit **140**. As illustrated in FIG. **6**, the plurality of first communication quality light-emitting units **130** and the reception intensity light-emitting unit **140** may be arrayed along the shape of a line graph that indicates relationship between the reception intensity of signals received from the base station **200** and the communication throughput of communication with the base station **200**. The plurality of first communication quality light-emitting units **130** are arrayed such that the leftmost one, as seen when looking at the figure, corresponds to the lowest communication quality level, and the communication quality level increases as the position of a first communication quality light-emitting unit **130** shifts rightward as seen when looking at the figure.

Thereby, it is possible to cause the relay apparatus **100** user to recognize intuitively what degree of communication throughput can be expected based on the position of a first communication quality light-emitting unit **130** that is emitting light. Also, it is possible to cause the relay apparatus **100** user to recognize intuitively, when the reception intensity light-emitting unit **140** emits light, that the communication quality is lowered because the reception intensity is too high.

FIG. **7** schematically illustrates another array example of the plurality of first communication quality light-emitting units **130** and the reception intensity light-emitting unit **140**. As illustrated in FIG. **7**, the position where a respective one of the plurality of first communication quality light-emitting units **130** is arranged may be higher as the position shifts rightward. Also, the reception intensity light-emitting unit **140** may be arranged on the right side of and lower than the rightmost first communication quality light-emitting unit **130** among the plurality of first communication quality light-emitting units **130**.

Thereby, it is possible to cause the relay apparatus **100** user to recognize intuitively what degree of communication quality can be expected based on the position of a first communication quality light-emitting unit **130** that is emitting light. Also, it is possible to cause the relay apparatus **100** user to recognize intuitively, when the reception intensity light-emitting unit **140** emits light, that the communication quality is lowered because the reception intensity is too high.

FIG. **8** schematically illustrates a display example of the display unit **304** of the communication terminal **300**. On the display unit **304**, a plurality of first communication quality objects **320**, reception intensity information **330**, a second communication quality object **340**, and a comment **350** are displayed.

The first communication quality indicating unit **110** may display, on the display unit **304**, a first communication quality object **320**, among the plurality of first communication quality objects **320** that correspond to respective ones of a plurality of communication quality levels, that corresponds to the first communication quality between the relay apparatus **100** and the base station **200**. The first communication quality indicating unit **110** may display, on the display unit **304**, only the first communication quality object **320** that corresponds to the first communication quality between the relay apparatus **100** and the base station **200**. Also, the first communication quality indicating unit **110** may display, on

the display unit **304** in addition to the first communication quality object **320** that corresponds to the first communication quality between the relay apparatus **100** and the base station **200**, first communication quality objects **320** that correspond to communication quality that is lower than the first communication quality. FIG. **8** illustrates an example in which when the first communication quality is at the level 10 among twelve levels, first communication quality objects **320** that correspond to the levels 1 to 10, respectively, are displayed on the display unit **304**.

The reception intensity indicating unit **106** displays the reception intensity information **330** on the display unit **304** when the reception intensity acquired by the reception intensity acquiring unit **104** has exceeded a predetermined threshold. Also, the reception intensity indicating unit **106** may display the reception intensity information **330** on the display unit **304** when a length of time during which the reception intensity acquired by the reception intensity acquiring unit **104** has exceeded a predetermined threshold has exceeded a predetermined length of time per unit time. Thereby, it is possible to prevent the reception intensity information **330** from being displayed on the display unit **304** when the reception intensity has exceeded a predetermined threshold momentarily. The reception intensity information **330** may have a shape that is identical with the first communication quality object **320** or may have a different shape. FIG. **8** illustrates a display example in which the reception intensity information **330** and the first communication quality object **320** have identical shapes.

The reception intensity indicating unit **106** may display the comment **350** on the display unit **304** in addition to the reception intensity information **330** when the reception intensity of radio waves received by the relay apparatus **100** from the base station **200** has exceeded a predetermined threshold. The comment **350** may be a message for indicating that the reception intensity is too high. Also, the comment **350** may be a message including advice to reduce the reception intensity of the relay apparatus **100**. For example, the comment **350** may be a message to recommend moving the relay apparatus away from a window.

The second communication quality indicating unit **116** displays the second communication quality between the relay apparatus **100** and the communication terminal **300** on the display unit **304**. The second communication quality indicating unit **116** may display the second communication quality object **340** on the display unit **304** as the second communication quality. Also, the second communication quality indicating unit **116** may display the comment **350** about the second communication quality on the display unit **304**. FIG. **8** illustrates a display example of the second communication quality object **340** when the second communication quality is at the level 3 among five levels.

Note that although an example in which the reception intensity indicating unit **106** displays the comment **350** on the display unit **304** was explained with reference to FIG. **8**, the first communication quality indicating unit **110** may display the comment **350** on the display unit **304**. When the first communication quality is calculated based on a plurality of values such as RSRP, RSRQ, and SINR, and the first communication quality is low, the first communication quality indicating unit **110** may display, as the comment **350** on the display unit **304**, because which value among the plurality of values is low the first communication quality is lowered. For example, when the first communication quality is half of or lower than the plurality of communication quality levels, the first communication quality indicating unit **110** may display, as the comment **350** on the display unit **304**, because which value among the plurality of values the first communication quality is lowered.

FIG. **9** schematically illustrates the relay apparatus **100** comprising a movable antenna cover **410**. The antenna cover **410** is made of a blocking member that blocks radio waves emitted from the base station **200**. In the example illustrated in FIG. **9**, the relay apparatus **100** has a built-in antenna, and depending on the position of the antenna cover **410**, the degree of blocking radio waves from reaching the built-in antenna changes.

For example, when the reception intensity indicating unit **106** indicates that the reception intensity has exceeded a predetermined threshold, the relay apparatus **100** user can adjust the reception intensity by moving the antenna cover **410** instead of moving the relay apparatus **100**. That is, by providing the antenna cover **410** to the relay apparatus **100**, the communication quality can be improved more easily.

FIG. **10** illustrates one example of the hardware construction of the relay apparatus **100**. The relay apparatus **100** comprises a CPU peripheral unit that has a CPU **504** and a RAM **506** that are interconnected by a host controller **502**, and an input/output unit that has a communication interface **510**, an LED control unit **516**, and an operation button **524** that are connected to the host controller **502** by an input/output controller **508**.

The host controller **502** connects the RAM **506** and the CPU **504** that accesses the RAM **506** at high transfer rate. The CPU **504** operates based on a program stored in the RAM **506**, and controls each unit. The input/output controller **508** connects the host controller **502**, the communication interface **510**, the LED control unit **516**, and the operation button **524**.

The communication interface **510** communicates with the base station **200** via an antenna **512**. Also, the communication interface **510** communicates with the communication terminal **300** via an antenna **514**. That is, the antenna **512** may be one example of the first communication unit **102**. Also, the antenna **514** may be one example of the second communication unit **112**.

The LED control unit **516** controls a first LED **518**, a second LED **520**, and a third LED **522**. The first LED **518** may be one example of the first communication quality light-emitting unit **130**. The second LED **520** may be one example of the reception intensity light-emitting unit **140**. The third LED **522** may be one example of the second communication quality light-emitting unit **150**. The operation button **524** may be one example of an operation button provided to the instructing unit **118**.

The program installed in and run by the relay apparatus **100** may act on the CPU **504** and the like to cause the relay apparatus **100** to function as the first communication unit **102**, the reception intensity acquiring unit **104**, the reception intensity indicating unit **106**, the first communication quality acquiring unit **108**, the first communication quality indicating unit **110**, the second communication unit **112**, the second communication quality acquiring unit **114**, the second communication quality indicating unit **116**, the instructing unit **118**, the control unit **120**, the first communication quality light-emitting unit **130**, the reception intensity light-emitting unit **140**, and the second communication quality light-emitting unit **150** that were explained with reference to FIGS. **1** to **9**.

Note that although in the present embodiment, an example in which the relay apparatus **100** comprises the second communication quality acquiring unit **114** and the second communication quality indicating unit **116** was explained, the relay apparatus **100** may not comprise the

second communication quality acquiring unit **114** and the second communication quality indicating unit **116**.

Also, in the present embodiment, an example in which the reception intensity indicating unit **106** indicates that the reception intensity has exceeded a predetermined threshold by using the reception intensity light-emitting unit **140**, or the display unit provided to the relay apparatus **100** or the communication terminal **300** was explained. However, the manner of indication is not limited thereto. For example, the relay apparatus **100** may indicate that the reception intensity acquired by the reception intensity acquiring unit **104** has exceeded a predetermined threshold by outputting sound such as a beep when the reception intensity has exceeded the predetermined threshold. Thereby, it is possible to allow a user to recognize that the reception intensity is too high even if the user is not gazing at the relay apparatus **100**.

The relay apparatus **100** may use light-emission of the reception intensity light-emitting unit **140**, display on the display unit, and sound output in combination. Also, the relay apparatus **100** may comprise any one of the reception intensity light-emitting unit **140**, the display unit, and a sound output unit. By using light-emission of the reception intensity light-emitting unit **140**, display on the display unit, and sound output in combination, it is possible to allow a user to surely recognize that the reception intensity is too high. Also, by providing any one of the reception intensity light-emitting unit **140**, the display unit, and the sound output unit, the number of components can be reduced.

Also, the relay apparatus **100** may comprise an operation button that can emit light, instead of the reception intensity light-emitting unit **140**. For example, the operation button is not caused to emit light when the reception intensity has fallen below the predetermined threshold, but that the reception intensity acquired by the reception intensity acquiring unit **104** has exceeded a predetermined threshold may be indicated by causing the operation button to emit light when the reception intensity has exceeded the threshold. Thereby, it becomes unnecessary to provide the reception intensity light-emitting unit **140**, and the number of components can be reduced.

While the embodiment(s) of the present invention has (have) been described, the technical scope of the invention is not limited to the above described embodiment(s). It is apparent to persons skilled in the art that various alterations and improvements can be added to the above-described embodiment(s). It is also apparent from the scope of the claims that the embodiments added with such alterations or improvements can be included in the technical scope of the invention.

The operations, procedures, steps, and stages of each process performed by an apparatus, system, program, and method shown in the claims, embodiments, or diagrams can be performed in any order as long as the order is not indicated by "prior to," "before," or the like and as long as the output from a previous process is not used in a later process. Even if the process flow is described using phrases such as "first" or "next" in the claims, embodiments, or diagrams, it does not necessarily mean that the process must be performed in this order.

What is claimed is:

1. A relay apparatus that relays wireless communication between a communication terminal and a base station, the relay apparatus comprising:

a non-transitory computer-readable recording medium having recorded therein a program, wherein the program causes a computer to perform functions including acquiring a first communication quality of communication with the base station, acquiring a reception intensity of a radio wave received from the base station, and acquiring a second communication quality of communication with the communication terminal;

a first communication quality indicating unit that indicates, to a user of the relay apparatus, the acquired first communication quality;

a reception intensity indicating unit that indicates, to the user of the relay apparatus, that the acquired reception intensity has exceeded a predetermined threshold; and

a second communication quality indicating unit that indicates, to the user of the relay apparatus, the acquired second communication quality, wherein

the first communication quality indicating unit indicates to which first communication quality level among a plurality of first communication quality levels the first communication quality corresponds,

the second communication quality indicating unit indicates to which second communication quality level among a plurality of second communication quality levels the second communication quality corresponds, and

the relay apparatus further comprises:

a plurality of first communication quality light-emitting units that correspond to respective ones of the plurality of first communication quality levels, the plurality of first communication quality light-emitting units being arrayed in the order of corresponding first communication quality levels; and

a plurality of second communication quality light-emitting units that correspond to respective ones of the plurality of second communication quality levels, the plurality of second communication quality light-emitting units being arrayed in the order of corresponding second communication quality levels.

2. The relay apparatus according to claim **1**, wherein

the first communication quality indicating unit indicates the first communication quality by causing a first communication quality light-emitting unit, among the plurality of first communication quality light-emitting units, that corresponds to the first communication quality to emit light.

3. The relay apparatus according to claim **2**, wherein the plurality of first communication quality light-emitting units are arrayed along a shape of a line graph that indicates relationship between reception intensity of a signal received from the base station and communication throughput of communication with the base station.

4. The relay apparatus according to claim **2**, wherein

the reception intensity indicating unit indicates that the reception intensity has exceeded a predetermined threshold by causing a reception intensity light-emitting unit to emit light, and

the plurality of first communication quality light-emitting units and the reception intensity light-emitting unit are arrayed along a shape of a line graph that indicates relationship between reception intensity of a signal received from the base station and communication throughput of communication with the base station.

5. The relay apparatus according to claim **2**, wherein

the reception intensity indicating unit indicates that the reception intensity has exceeded a predetermined threshold by causing a reception intensity light-emitting unit to emit light, and

the reception intensity light-emitting unit is arranged at a position that is adjacent to a first communication quality light-emitting unit, among the plurality of first

communication quality light-emitting units, that corresponds to a highest first communication quality level.

6. The relay apparatus according to claim 1, wherein the reception intensity indicating unit indicates that the reception intensity has exceeded a predetermined threshold by outputting sound.

7. The relay apparatus according to claim 1, wherein

the first communication quality indicating unit displays the first communication quality on a display unit, and

the reception intensity indicating unit displays on the display unit reception intensity information that indicates that the reception intensity has exceeded the predetermined threshold.

8. The relay apparatus according to claim 7, wherein

the first communication quality indicating unit displays the first communication quality on the display unit provided to the communication terminal, and

the reception intensity indicating unit displays, on the display unit provided to the communication terminal, reception intensity information that indicates that the reception intensity has exceeded the predetermined threshold.

9. The relay apparatus according to claim 7, wherein the first communication quality indicating unit displays on the display unit an object, among a plurality of objects that correspond to respective ones of a plurality of first communication quality levels, that corresponds to the first communication quality of communication with the base station.

10. The relay apparatus according to claim 7, wherein the reception intensity indicating unit displays on the display unit the reception intensity information and a message including advice to reduce reception intensity of the relay apparatus.

11. The relay apparatus according to claim 7, wherein the reception intensity indicating unit displays on the display unit the reception intensity information when a length of time during which the acquired reception intensity has exceeded a predetermined threshold has exceeded a predetermined length of time per unit time.

12. The relay apparatus according to claim 1, further comprising an antenna cover that is movable and made of a blocking member to block a radio wave emitted from the base station, the antenna cover changing in a degree of blocking a radio wave from reaching a built-in antenna depending on a position of the antenna cover.

13. The relay apparatus according to claim 1, further comprising an instructing unit that, when pressing of an operation button is detected, executes at least either of: instructing the computer to acquire reception intensity of a radio wave received from the base station; and instructing the computer to acquire the first communication quality.

14. The relay apparatus according to claim 13, wherein when pressing of the operation button is detected, the instructing unit continues instructing the computer to acquire the first communication quality for a predetermined length of time.

15. The relay apparatus according to claim 14, wherein when pressing of the operation button is detected, the first communication quality indicating unit continuously indicates the first communication quality until the predetermined length of time elapses since the operation button is pressed.

16. The relay apparatus according to claim 1, wherein

the first communication quality is acquired based on RSRP, RSRQ, and SINR of communication with the base station, and

when the first communication quality is lower than predetermined quality, the first communication quality indicating unit displays on a display unit because which value among the RSRP, the RSRQ, and the SINR is low the first communication quality is lowered.

17. A non-transitory computer-readable recording medium having recorded therein a program, wherein the program causes a computer to perform functions comprising:

acquiring a first communication quality of communication with a base station;

indicating, to a user, the acquired first communication quality;

acquiring a reception intensity of a radio wave received from the base station;

indicating, to the user, that the acquired reception intensity has exceeded a predetermined threshold;

acquiring a second communication quality of communication with a communication terminal; and

indicating, to the user, the acquired second communication quality, wherein

the indicating the acquired first communication quality includes indicating to which first communication quality level among a plurality of first communication quality levels the first communication quality corresponds,

the indicating the acquired second communication quality includes indicating to which second communication quality level among a plurality of second communication quality levels the second communication quality corresponds, and

the program further cases the computer to perform functions comprising:

causing a plurality of first communication quality light-emitting units to emit light, the plurality of first communication quality light-emitting units corresponding to respective ones of the plurality of first communication quality levels and being arrayed in the order of corresponding first communication quality levels, and

causing a plurality of second communication quality light-emitting units to emit light, the plurality of second communication quality light-emitting units corresponding to respective ones of the plurality of second communication quality levels and being arrayed in the order of corresponding second communication quality levels.

* * * * *